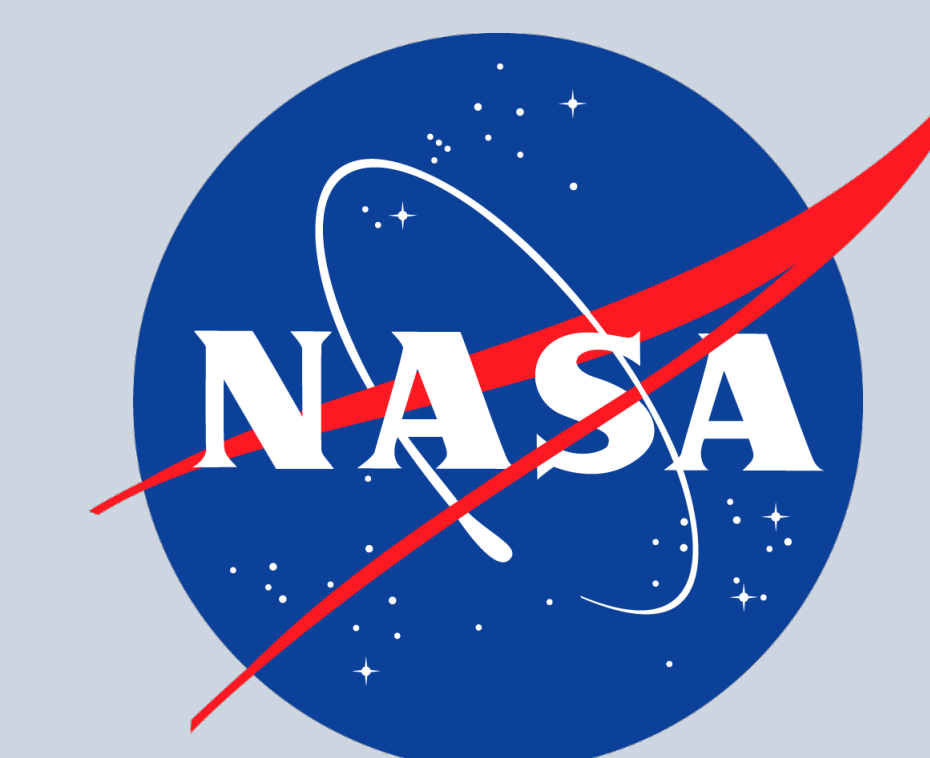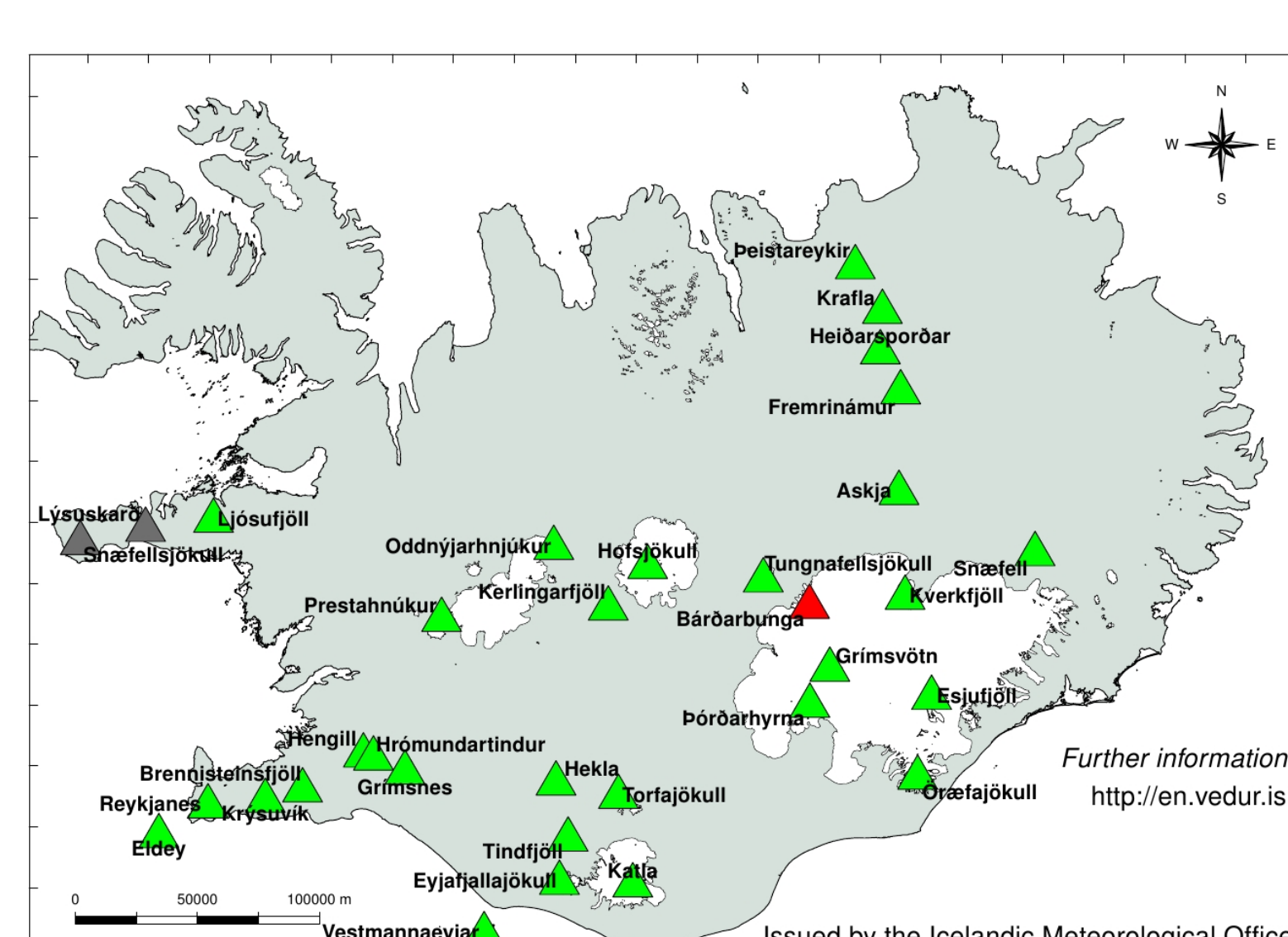# TIR-Based Volcanic SO$_2$ Science Products for Terra, Aqua, and Suomi NPP

Vincent J. Realmuto
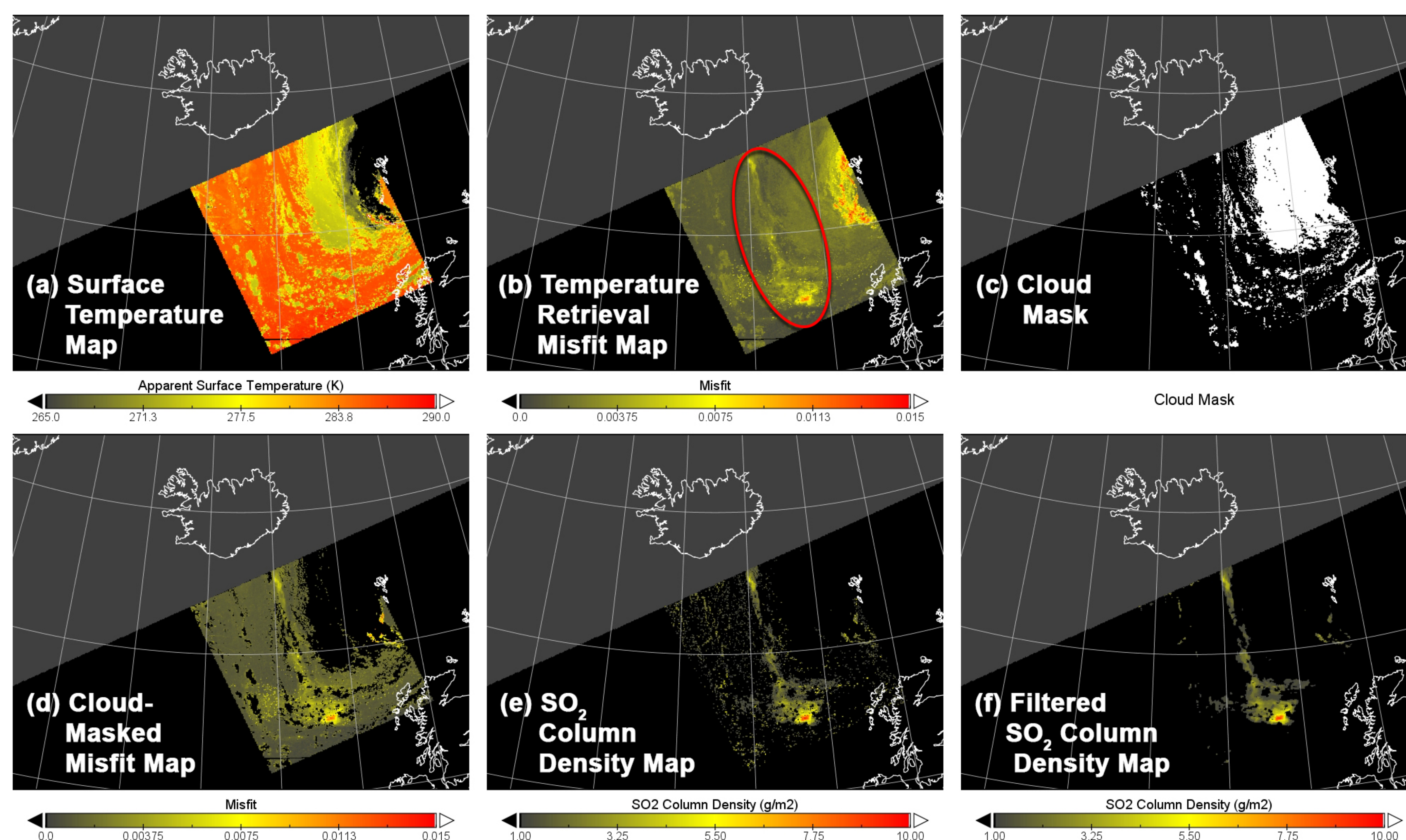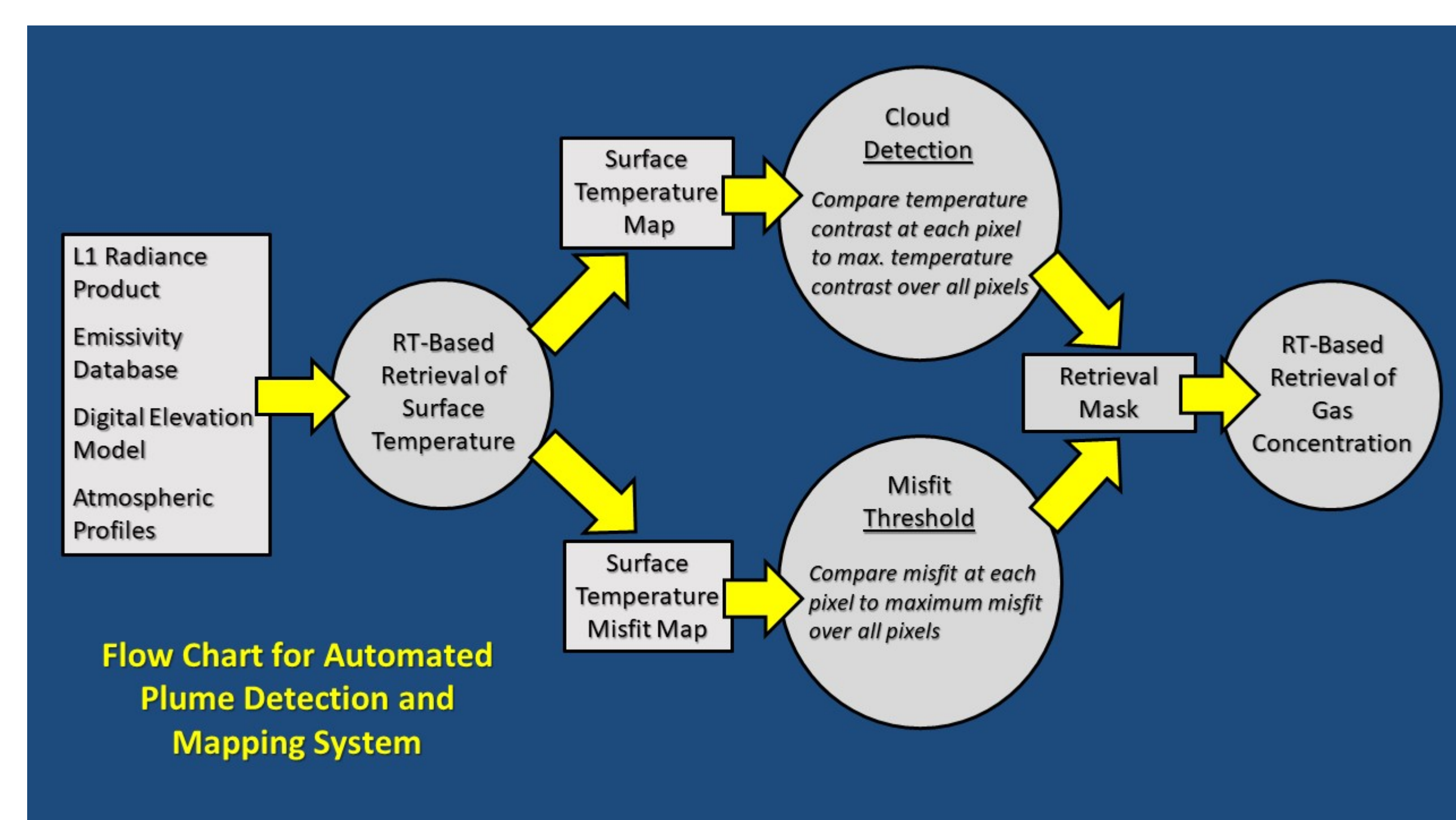## Jet Propulsion Laboratory, California Institute of Technology

Objectives

- Develop a prototype system for the automated detection and mapping of volcanic SO2 plumes based on multispectral TIR image data
- Validate system and data products through analysis of MODIS, VIIRS, and ASTER data records for the long-lived (29 August 2014 – 27 February 2015) eruption of Bardarbunga Volcano, Iceland
- Prepare and submit Algorithm Theoretical Basis Documents (ATBD) to MODIS, VIIRS, and ASTER Projects for future inclusion of plume detection and mapping system in corresponding Product Generation Systems (PGS)

2014-09-01
Courtesy of Daily Telegraph

Holuhraun Fissure Eruption, Bardarbunga Volcano, Iceland

Further information
http://en.vedur.is

Issued by the Icelandic Meteorological Office

Plume Detection and Mapping

- Estimate Surface Temperature
- Derive Plume and Cloud Masks from Temperature Estimates
- Combine Plume and Cloud Masks to Make Gas Retrieval Mask
- Estimate Gas Column Density Within Retrieval Mask

Flow Chart for Automated Plume Detection and Mapping System

L1 Radiance Product
Emissivity Database
Digital Elevation Model
Atmospheric Profiles

RT-Based Retrieval of Surface Temperature

Surface Temperature Map

Cloud Detection — Compare temperature contrast at each pixel to max. temperature contrast over all pixels

Surface Temperature Misfit Map

Misfit Threshold — Compare misfit at each pixel to maximum misfit over all pixels

Retrieval Mask

RT-Based Retrieval of Gas Concentration

(a) Surface Temperature Map
Apparent Surface Temperature (K)
265.0   271.3   277.5   283.8   290.0

(b) Temperature Retrieval Misfit Map
Misfit
0.0   0.00375   0.0075   0.0113   0.015

(c) Cloud Mask
Cloud Mask

(d) Cloud-Masked Misfit Map
Misfit
0.00375   0.0075   0.0113   0.015

(e) SO$_2$ Column Density Map
SO2 Column Density (g/m2)
1.00   3.25   5.50   7.75   10.00

(f) Filtered SO$_2$ Column Density Map
SO2 Column Density (g/m2)
1.00   3.25   5.50   7.75   10.00

Terra Overpasses 2014-09-05

Aqua Overpasses 2014-09-05

SNPP Overpasses 2014-09-05

VMAE Channel 14 Brightness Temperature Difference 2014-09-05 (03:15 UTC)

(a) VMAE: 03:15 UTC

MODIS-Aqua Channel 29 Brightness Temperature Difference 2014-09-05 (03:25 UTC)

(b) MODIS-Aqua: 03:25 UTC

VMAE Channel 14 Brightness Temperature Difference 2014-09-05 (04:55 UTC)

(c) VMAE: 04:55 UTC

MODIS-Terra Channel 29 Brightness Temperature Difference 2014-09-05 (12:50 UTC)

(d) MODIS-Terra: 12:50 UTC

MODIS-Aqua Channel 29 Brightness Temperature Difference 2014-09-05 (13:00 + 13:05 UTC)

(e) MODIS-Aqua: 13:00 UTC

VMAE Channel 14 Brightness Temperature Difference 2014-09-05 (13:05 + 13:10 UTC)

(f) VMAE:13:05 UTC

VMAE Channel 14 Brightness Temperature Difference 2014-09-05 (14:50 UTC)

(g) VMAE: 14:50 UTC

MODIS-Terra Channel 29 Brightness Temperature Difference 2014-09-05 (22:30 UTC)

(h) MODIS-Terra: 22:30 UTC

Brightness Temperature Difference (K)
-10.00   -7.50   -5.00   -2.50   0.00

(a) VMAE 03:15 UTC

(b) MODIS 03:25 UTC

SO2 Column Density (g/m2)
0.0   5.0   10.0   15.0   20.0

(a) SNPP-OMPS Total Mass: 149.5 kt

SNPP/OMPS TRL Sq (DU)
20.00
16.67
13.33
10.00
6.67
3.33
0.00

(b) VIIRS-VMAE Total Mass: 150 kt

GAS COLUMN DENSITY
35   245   455   665   875   (DU)
1.0   7.0   13.0   19.0   25.0   (g/m2)